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SOURCES AND EFFECTS OF PESTICIDES IMPACTING STREAM ECOSYSTEMS

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Groundwater and surface water resources are under increasing pressure from multiple stressors. These include chemical stressors, physical stressors, i.e. changes in land use leading to alterations in stream hydromorphology, and hydraulic pressures such as groundwater abstraction. Pesticides are among the most harmful class of compounds impacting surface waters, particularly since they have been so widely used to control the occurrence of pests and weeds in urban and agricultural landscapes. In order to properly identify and subsequently mitigate the impacts to surface water ecosystems, a better understanding of the sources and types of pesticides expected in surface waters is essential. This paper therefore aims to (i) assess current trends for pesticide concentrations in surface water, (ii) identify the types of pesticides leading to a surface water impact and (iii) determine their pathways into surface waters. In particular, there are few studies investigating the importance of groundwater as a pathway for pesticide impacts to ecosystems. Also, particulate-bound pesticides have long been disregarded as an important source of ecotoxicity, due predominantly to an assumed reduction in bioavailability.

The following sources for pesticides in headwater streams were thus investigated: chronic exposure due to groundwater inflow, acute exposure due to storm-water runoff, and the presence of particulate-bound pesticides in storm-flows. Pesticide analyses, including impacts to benthic macroninvertebrates – calculated using the toxic units (TU) approach – are presented for twelve sampling locations in two watersheds in Denmark. Biomonitoring was conducted using the traditional Danish Stream Fauna Index (DSFI) and the more recent SPEcies At Risk (SPEAR) index, which can be coupled to the TU in order to identify the sources of ecotoxicity .

Results show that pesticides were essential contributers to the overall ecological impairment of the studied streams. This was determined using the newer SPEAR index, but was not recognized by the older DSFI method. Chemical toxicity analyses identified particulate-bound insecticides such as chlorpyrifos and hexachlorobenzene as the primary source for ecotoxicity in the studied streams, even when using a safety factor to account for a decreased bioavailability of the particulate-bound contaminants. Evaluation of the origin of pesticides indicated groundwater inflow as an important source of pesticides entering streams. Notably, there was little correlation between pesticide concentrations measured in streams and estimated current use. Although dissolved-phase stream concentration levels, both from baseflow and storm-flow, were not found to be a contributing factor to stream toxicity, they are strong indicators of the deteriorated water quality in the surrounding groundwater water resources. Pesticides such as diuron and isoproturon, which were banned long ago and are on the European priority pollutant list, were found in all monitored surface water, showing that these compounds are more persistent than previously thought. We suggest that the mechanisms for ecotoxicity, and pathways into surface water following a history of pesticide use spanning many decades, are not sufficiently understood. This work demonstrates that groundwater and particulate-borne pesticides will impact streams for many years into the future. More comprehensive knowledge on particulate and sediment-bound contaminants and their effects on stream ecosystems could be a key factor necessary for successful river restoration projects.

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